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ENVIRONMENTALLY SOUND MANAGEMENT OF SOLID WASTES AND SEWAGE-RELATED ISSUES: BACKGROUND

Report of the Secretary-General of the Conference

I. INTRODUCTION

1. By its decision 2/16, the Preparatory Committee for the United Nations Conference on Environment and Development (UNCED) requested the Secretary-General of the Conference to submit to the Preparatory Committee at its third session the potential areas for action which could form the framework of an international strategy for the environmentally sound management of solid wastes and sewage. The present report provides the background and basis for elaborating options for an action programme on the subject of solid waste management and sewage disposal. The report seeks to elicit the principal issues governing effective waste management, attempts to identify present day constraints and gaps in knowledge and reviews current approaches and activities in waste management. On the basis of this analysis, a complementary second report A/CONF.151/PC/42 Add.10 provides the basis for a possible action programme for incorporation within Agenda 21.

2. The present report addresses each of the subject items included in decision 2/16 albeit in a revised sequence to provide a coherent overview of the principal issues governing sound waste management and present, in perspective, their linkages to both environment and development. The report

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reviews trends in waste generation, and analyses the underlying issues in critical areas related to waste management such as the health and environmental aspects; linkages to human settlements and development planning; technologies; waste minimization; capacity building; information exchange and funding. A review of current programmes and activities are also included.

3. This report focuses on solid wastes, human excreta and sewage. Solid wastes include domestic refuse, commercial and institutional wastes, street sweepings and construction debris. While it is possible that these municipal wastes will contain some industrial waste materials and discharges, the report assumes that hazardous wastes and toxic chemicals, which must be kept out of municipal sewers and landfills, will not form part of municipal solid wastes and sewage. Although this is not always a valid assumption it is a precondition to gaining effective control over traditional forms of pollution.

4. In preparing this report account has been taken of decision 1/22 of the first session of the Preparatory Committee and document A/CONF.151/PC/34 presented at its second session. The report has, in addition, drawn upon the views expressed in relevant paragraphs of the Bergen Declaration, the Tlatelolco Platform on Environment and Development and the Ministerial Declaration on Environmentally Sound and Sustainable Development in Asia and the Pacific convened to provide inputs to UNCED.

5. The report was prepared by the UNCED secretariat on the basis of contributions from the United Nations system of organizations and specialized agencies. The Secretary-General of the Conference gratefully acknowledges, in particular, the useful and extensive contributions received from the United Nations Centre for Human Settlements (Habitat), the World Health Organization and the World Bank. Non-governmental organizations, in particular the International Solid Waste Association, academic and research institutions also provided useful inputs.

II. WASTE GENERATION

A. Human excreta and sewage

6. On average each person excretes 350 grams of solids and 1.8 litres of liquid each day which together are called excreta. In addition, between 70 and 80 per cent of water used is not consumed but is returned to the environment either directly or through some form of sanitation facility sewer or drainage system. The mixture of such non-consumptive waste water and excreta comprise sewage. Where water usage is low, the pollutant concentration of the resulting sewage remains high. The average per capita water usage in industrial countries varies between 100 and 300 litres while that in developing countries varies between 30 and 150 litres. Consequently, the sewage produced in developing countries is often more concentrated with organic pollutants. On the other hand, the inappropriate discharge of numerous industrial effluents into sewerage networks in many industrialized countries increases both the concentration and variety of pollutants where this takes place.

7. Most of the industrialized world has a stable population, is highly urbanized (usually over 80 per cent) and has both extensive sewer networks to collect all sewage generated in urban areas and corresponding facilities to treat them effectively before discharging effluents into the environment. The reverse is true for developing countries where populations continue to grow at a rapid rate, especially in urban areas, and where less than half the total population has access to even the most basic form of sanitation. Excluding China, an estimated 400 million urban dwellers and 1,500 million rural dwellers lack access to adequate sanitary means of disposing of excreta. The concerted efforts to increase sanitation coverage during the International Drinking Water Supply and Sanitation Decade (1981-1990) were only sufficient to ensure that sanitation coverage kept pace with population growth. By the year 2000, an estimated 625 million urban dwellers and 1,700 million rural dwellers will remain unserved. Half of the new urban dwellers will lack sanitation facilities. An estimated 1.35 million tons of human excreta will be discharged in and around urban agglomerations each day along with a similar amount of human waste-derived sludges.

8. While gross statistics suggest the problem in rural areas would be more than twice that in urban areas, owing to the concentration of populations, the environmental and health problems associated with inadequate human waste disposal are most critical in urban areas. In rural areas there is more natural capacity to absorb wastes. Urban wastes, on the other hand, have long exhausted the capacity of nature to assimilate them. Even in the more advanced developing countries, sewerage services are available to only about half the population and the proportion decreases to less than 15 per cent in the case of low-income countries. Unserved populations use one of a variety of on-site sanitation systems such as septic tanks or have no sanitation facilities at all. In developing countries, of the sewage collected through sewerage systems less than 10 per cent is treated adequately before discharge to water courses. In Latin America, it is estimated that less than 2 per cent of total urban sewage flows receive adequate treatment. Even where on-site sanitation systems are utilized, much of the non-wastewater, or greywater, finds its way into surface drains and thence into natural watercourses.

B. Solid wastes

9. As is the case with human wastes and sewage, the problems of solid waste disposal are accentuated in urban areas. City-wide average rates of waste generation in most industrialized countries lie between 1.0 and 2.5 kg/capita/day and in some cases even as high as 3.0 kg/capita/day. In developing countries the average generation rate is within the range of 0.2 to 0.5 kg/capita/day. Low-income areas within urban centres in developing countries frequently generate the smallest quantities of waste; at times, as little as half the city-wide average. In terms of proportions, household waste accounts for the bulk - usually up to 75 per cent of the total quantity of wastes. Household solid wastes, together with commercial, institutional, non-toxic industrial and street wastes, account for over 90 per cent of all urban wastes in developing countries. At best, developing country cities collect 70 per cent of solid wastes generated each day while, at the other extreme, in low-income countries as little as 30 per cent of the solid wastes generated each day are presently collected. Landfill remains the most common form of disposing of solid wastes and most, if not all such landfills are run

as open dumps with sanitary landfills being the exception rather than the rule. Solid waste disposal operations absorb between 30 and 50 per cent of municipal operating budgets and hence there is considerable scope for improved management. Industrialized-country refuse contains substantial amount of packaging materials which are more persistent in the environment though light in weight. Consequently, the density of industrialized country solid waste is typically only a fraction that of developing country refuse which contains a large proportion (40 to 60 per cent) of organic matter such as food wastes which are readily biodegradable.

C. Waste trends

10. As recognized in the Bergen Ministerial Declaration on Sustainable Development in the ECE region, unsustainable patterns of production and consumption, particularly in industrialized countries, are at the root of numerous environmental problems. The truth behind this statement is eminently illustrated when comparing both present day generation rates and composition of wastes in industrial countries with those for developing countries. The total annual amount of urban wastes (excluding construction debris) generated worldwide is estimated at 720 billion tons of which 440 billion is in industrialized countries and 280 billion in developing countries. Likewise worldwide liquid waste generation in cities amounts to 52 billion cubic meters of which 37 billion is generated in industrialized countries and 15 billion in developing countries.

11. The quantities of wastes generated in developing countries are increasing rapidly and may double by the end of the decade. There are two reasons for this. First, demographic changes, especially in urban areas, where average growth is about 3.6 per cent, will lead to the generation of greater quantities of wastes. Second, industrialization and economic growth will increase per capita quantities and change the composition. By the year 2025, when over 60 per cent of the world's population, some 5 billion people, will live in urban areas, a five-fold increase in the quantities of waste generated could result. In developing countries, per capita levels of waste by 2025 would still be only one fifth today's average industrial country generation. Most European countries saw a tripling of their per capita waste quantity generation over the last two decades. This was accompanied by a decrease in the biodegradability of the wastes as more and more non-organic materials and industrial wastes were discharged together into municipal wastes facilities.

12. Costs are also increasing. As cities grow, they exhaust the capacity of traditional disposal sites so that wastes must be transported greater distances to sites outside the city. The explosion of satellite communities in most developing country cities has made this problem reach crisis proportions. City managers are therefore struggling with a common problem: how to dispose of ever-growing amounts of wastes in an environment of dwindling available land space. Increases in costs are pervasive. Some cities in the United States have experienced an eight-fold increase in waste disposal costs over the last decade.

III. ENVIRONMENTAL, DEVELOPMENTAL AND HEALTH ASPECTS OF WASTE MANAGEMENT

A. Environmental linkages

13. Inadequate solid waste, human excreta and sewage disposal can cause serious and long-term pollution of land, air and water resources. Waste disposal is perhaps the single most important influence on the quality of the human living and working environment. Also, large areas of land in or near urban areas have been made unusable by the indiscriminate dumping and accumulation of wastes. Housing near past and active disposal sites has been threatened by explosive gases generated by decomposing wastes.

14. Land disposal of sewage and/or sludge pollute the soil with eggs of parasite worms and heavy metals. Water seeping through wastes at solid waste disposal sites, also called leachate, are significant sources of nitrate and heavy metal pollution of groundwater. Extensive impermeable areas in towns and cities give rise to large quantities of rainfall run-off which become contaminated by waste and cause pollution of surface water. Stormwater drainage systems are often combined with sanitary sewerage. Stormwater frequently contains domestic wash waters, sewage and industrial effluent which together contribute significantly to pollution of both surface and groundwater. It is often presumed that sewage is the principal source of surface water pollution. However, recent studies conducted in some large Asian cities have found solid waste to be equally, if not more, damaging to surface water resources. Indiscriminate disposal of solid wastes also increases the chances of flooding, with its associated environmental impacts.

15. Surface waters receiving municipal wastes have a natural assimilative capacity to absorb a certain quantity of waste materials without seriously impairing water quality. If the natural assimilative capacity for biodegradable organic matter is exceeded, the dissolved oxygen level in the water will drop to a point where it will be unsuitable for many uses, for example, to support fish life or, without extensive treatment, for water supply downstream. The indiscriminate discharge of wastes directly into the river near most developing country cities has rendered the water unfit for human consumption and unable to support aquatic life. Data for 24 rivers in Central and South America reveal that over half the rivers sampled showed fecal coliform counts in excess of 1000 per 100 milliliters. (Safe drinking water is required to have none of these human excreta-related organisms). Similar samples in Asia found most natural watercourses to be no more than open sewers.

16. Another problem which can arise from the discharge of wastes to surface waters, including rivers, lakes and coastal marine waters, is eutrophication. Wastes contain many plant nutrients especially nitrogen and phosphorus which give rise to the prolific growth of algae and aquatic plants. Excessive blooms of algae and growth of aquatic weeds can adversely affect the legitimate uses of the receiving water. In rapidly industrializing coastal cities, the appearance of algae blooms cause a pervasive "red tide" and the contamination of shellfish and other aquatic species. Freshwater bodies in other cities demonstrate "pea-soup" green algal blooms. The discharge of

sewage sludges into coastal water cause similar polluting effects and remains a global concern. However, these same "problem" pollutants can be turned to beneficial use as nutrients when, after appropriate treatment, the sewage liquids are used for irrigation or aquaculture.

17. Air is polluted by particulates in effluents and smoke from burning refuse. Uncontrolled solid waste dumps release methane due to the breaking down of organic materials. This often leads to spontaneous combustion of solid wastes. The extent to which waste-related releases of both methane and carbon dioxide contribute to atmospheric greenhouse gases, relevant to climate change and rising sea levels, has yet to be adequately assessed. Even large modern refuse incinerators produce toxic gases when plastics are burned. Uncollected wastes are a physical nuisance and a source of olfactory and aesthetic pollution. Liquid and solid waste treatment plants are also sources of noise and act as sources of food for scavenging animals and birds.

B. Health linkages

18. The linkages between health and the environment are discussed in document A/CONF.151/PC/54. Only a brief description of the health impacts of inadequate waste management is presented here. Human excreta and sewage contain disease causing pathogenic viruses, bacteria, protozoa and helminths. Fortunately, many factors limit disease transmission. For a human health risk to occur, a person must be exposed to an infective dose of a virulent pathogen and the infection has to either cause a disease or be further transmitted. The state of health and immunity of the recipient will have an effect on whether an actual or a potential risk exists after exposure. In the absence of adequate waste disposal, large sections of developing country populations live in an environment that does not isolate them from disease agents. Children, especially infants, are at greatest risk from pathogens transmitted through wastes, especially human excreta. With a high risk of exposure to faecal pathogens, many age groups in the community succumb to diarrhoeal diseases. For rural areas, satisfactory types of pit latrines are available, but where a high concentration of population exists, the land cannot assimilate the large amounts of human wastes and excreta and a serious health problem results. The incidence of intestinal worm infections in such high density settlements can reach as much as 50 per cent of the total population. Inadequate human excreta disposal has contributed to the recent cholera epidemic in Peru, and to its possible spreading to other countries in the American region.

19. Flies, mosquitoes, rats and cockroaches, which are either active or passive carriers of disease, breed or feed on wastes. Their numbers are closely related to the extent and quality of waste disposal services available in residential areas. These vectors are responsible for the transmission of a variety of diseases. The domestic fly, for example, breeds in fresh excreta and food wastes and is a major carrier of enteric bacteria such as salmonella and shigella. Ponds of sewage are breeding grounds for the culex mosquitoes, the vector of filariasis. Vegetables, fish and meat can be contaminated by inadequate waste disposal and cause a number of bacterial and parasitic infections. In 1985, the total number of deaths resulting from infections or parasitic diseases for which improper waste disposal is a significant risk

factor was estimated at 5.2 million of which 4 million were children under 5 years of age. Improper solid wastes disposal also result in the spreading of sharps which are the cause of injury and infections (tetanus).

20. In many developing country cities, as much as 1 to 2 per cent of the population derive their subsistence either directly or indirectly from the occupation of scavenging waste dumps to retrieve various discarded materials. Besides obstructing the smooth operation of waste collection and disposal services, scavenging places expose those involved to special risks of infection and injury. An additional health threat associated with waste disposal sites is the release of particulate matter from smouldering refuse which affects the respiratory system of man.

C. Information and methodology for preventing waste-related epidemics

21. There is, at present, a sufficient body of knowledge and information to estimate the extent to which human beings are affected by waste-related infections and the conditions under which such infections reach epidemic proportions. Methodologies for monitoring waste-related health risks are well established, including information on when such risks are likely to manifest as disease, taking account of factors such as pathogen survival time and persistence in different environments, infective dosage requirements and host susceptibility. Prevention of waste-related infections and epidemics is therefore not constrained by a lack of information or corresponding methodologies for their monitoring and implementation. The reasons why waste-related diseases are not prevented lie elsewhere.

22. Globally the number of people sick of waste-related disease at any one time, is estimated by the World Health Organization (WHO) as follows:

- Diarrhoeal diseases: Amoebiasis - 480 million
  Giardiasis - 200 million
  Typhoid - 1 million
  Cholera - 0.2 million

- Worm infections: Ascariasis - 700 million
  Hookworm - 800 million
  Trichuriasis - 500 million

23. To the above would need to be added a range of vector-borne diseases. Infectious and parasitic diseases cause 4.6 per cent of all deaths in industrialized countries but are responsible for as many as 45 per cent of deaths in developing countries and 72 per cent of deaths of children under five years of age in these countries.

24. In all, WHO estimates that each year some 1.8 billion people suffer from infectious diseases, preventable through hygienic waste disposal. While in some cases, efficient vaccines are available, there is no substitute for hygienic human excreta disposal to prevent diseases such as intestinal helminthiasis. Basic sanitation also remains the key to cholera and amebiasis prevention. The vaccine for cholera for example is only effective for six months and only successfully immunizes 60 per cent of recipients. As the development of effective and affordable vaccines to control enteric

parasitosis is unlikely to be successful if tried, the isolation of human excreta from human contact remains the simple most effective way of preventing extra-borne infections and epidemics. As seen in Latin America earlier this year, without adequate waste management countries remain under the constant threat of the resurgence of diseases such as cholera which can quickly reach epidemic proportions. Suitable waste disposal, the provision of adequate quantities of water for personal hygiene coupled with health education provide the best means of achieving infection abatement and prevention. The hygienic disposal of human excreta, appropriately complemented with the supply of adequate water and hygiene education, could reduce diarrhoeal disease prevalence by between 20 to 40 per cent.

25. Designing human excreta disposal systems and sewage treatment facilities in a way that will ensure the die-off of most, if not all, pathogens is well established. For example designing sewage treatment facilities such that they retain incoming wastewaters for a total of over 20 days in most hot climates will ensure the almost total removal of all pathogens found in the incoming sewage. Similarly, the composting of sewage sludges and organic solid wastes will, by elevating temperatures to over 60 degrees centigrade, destroy all pathogens including persistent helminth ova. On the other hand, poorly designed waste disposal facilities serve as a source for the transmission of other diseases. For example, poorly designed septic tanks are the principal breeding ground for the mosquito responsible for transmitting Bancroftian Filariasis.

26. Public health services monitor and report cases of enteric infection. Much can be done to widen the scope of such epidemiological surveillance to include waste-related rodent and insect carrier populations. Some diseases, such as cholera, which are subject to international reporting in conformity with agreements, are better monitored than others. The dissemination of appropriate techniques for epidemiological surveillance and the use of modern geographical information systems could contribute substantially to efforts to reduce waste-related infections and epidemics. The mounting of an appropriate vaccination campaign among high risk communities when a safe, efficient and affordable vaccine is available could serve as an additional control measure. Clearly the first priority must remain hygienic waste disposal.

D. Developmental linkages

27. Inadequate waste disposal impacts on national wealth and productivity in many ways. The impact on human health is perhaps the most significant. Over 80 per cent of all diseases and over one-third of deaths in developing countries are caused through the ingestion of waste contaminated food and water. One estimate suggests that as much as one tenth of each person's productive time in developing countries is sacrificed to waste-related diseases. The economic burden of the resulting expenses in curative medicine and loss of productivity have significant impacts on overall national development. Beyond the economic burden there is the cost of human misery and lowered quality of life suffered by millions of the world's populations, especially the poor.

28. Inadequate waste management often increases the cost of potable water by obliging authorities to go to increasingly remote sources to find water of acceptable quality. For example, in Shanghai, pollution from wastes forced city officials to move water intakes more than 40 kilometers. In Lima, upstream pollution increased treatment costs by about 30 per cent. Goods produced in areas where safe water is only available at a premium, can prove non-competitive in international markets.

29. While the inadequate disposal of wastes give rise to a number of environmental problems that contribute toward unsustainable patterns of development, sound waste management policies provide exceptional opportunities for enhancing the environment and supporting development. Recycling metals, paper, glass, plastics, and organic wastes and reusing wastewaters lessens the demand for energy, raw materials, fertilizers, foreign exchange and water resources. Producing aluminum from scrap instead of from bauxite cuts energy requirements for the resulting aluminum by 95 per cent. Making paper from discards instead of virgin timber not only saves valuable forests, it reduces the energy used per ton by up to three-quarters and requires less than half as much process water. The waste disposal service industry, when fully developed, could employ as much as between 1 to 2 per cent of the national work force.

IV. HUMAN SETTLEMENTS PLANNING AND WASTE

A. Human settlements linkages

30. All human and solid wastes originate in human settlements. While improved health and environmental protection are the principal objectives of managing wastes, many of the intervening actions to achieve these objectives are taken at the human settlements planning and implementation stage. Most waste disposal systems are designed and constructed as an integral part of housing and physical development: new housing schemes and informal settlement upgrading programmes include the provision of in-house waste disposal facilities and connection to collective infrastructure. Likewise, waste disposal infrastructure is provided as a component of commercial and industrial area development. Consequently, it is within the framework of human settlement planning, development and upgrading that many of the opportunities to promote cost-effective and environmentally-sound waste management practices arise. Effective waste management, therefore, requires a human settlements approach to waste disposal.

31. All people live and work in human settlements. Therefore, their quality is the principal determinant of the quality of the living and working environment. Inadequate waste management is one of the important factors which can degrade the quality of life, and at the same time reduce the capacity of settlements to contribute to economic development.

32. Efficient decisions on the type of waste disposal facilities that need to be provided depend on human settlement patterns. Waste disposal requirements for medium and high-rise building development are different from those of a detached house. In general, as densities increase, economies in waste management result and options for in-situ waste disposal decrease.

33. Appropriate building codes and regulations are an effective tool in ensuring that urban development takes place with adequate provision of waste disposal infrastructure. However, many developing countries have tended to adopt standards better suited to industrialized countries. These have resulted in infrastructure which has proven excessively costly to build and maintain. Such standards make illegal the use of a wide range of low-cost intermediate technologies. As one example, these regulations can be changed to permit the use of recycled waste and the re-use of treated waste effluents and waste-derived compost to maintain green areas and thereby enhance the living environment.

34. Human settlement development patterns can also suggest how waste disposal services can be provided to different urban areas and neighbourhoods. As previously indicated, in some developing countries as much as 70 per cent of urban waste remains uncollected. Large sections of the city receive little or no waste collection services which tend to concentrate in more affluent neighbourhoods. Even in the absence of municipal waste disposal services, the residents of these high-income and middle-income areas often have the financial capacity to make alternative arrangements.

35. It is the urban informal settlements, where between 30 and 60 per cent of the urban population lives, which are deprived of waste disposal services and even when such services are provided, their frequence and reliability is much lower than that provided to middle-income and high-income areas. Yet it is in low-income informal settlements, where population densities and health risks are high and the awareness of the hazards of uncontrolled waste disposal low, that the need for these services is greatest. As recent events in Latin America indicate, such informal settlements can become the epicentre of epidemics capable of spreading with little regard to local and national frontiers. Women and children are the ones most affected.

36. Therefore, the provision of waste disposal services to low-income informal settlements is a public health and environmental priority. Experience has proven that the residents of low-income informal settlements, despite their meagre economic means, are willing to invest in improving the environmental conditions of their living environments when some form of regulation and tenure security is provided through participatory arrangements with municipal and other public authorities.

37. Most informal settlements are located on land unsuitable for residential development, such as low-lying lands and steep slopes, some of which are ecologically sensitive. Poor waste management can jeopardise the biological viability of these lands. The same applies to human settlements in general, especially coastal human settlements, where poor waste management has far-reaching impacts on contiguous land and water resources. Land-based marine pollution, for example, is an increasing problem originating, to a large degree, from inadequate waste management in human settlements.

B. Integrating waste management with development plans

38. For comprehensive and strategic waste management it is necessary that waste management strategies be closely integrated with physical land use and development plans. Without this, waste management policies will operate below the potential optimum.

39. Based on settlement topography, type and size, there is a need to reserve and protect for present and potential future uses land sites in optimal locations for waste management infrastructure facilities such as sewage pumping stations and solid-waste transfer stations. Similarly, sufficient land is needed for waste treatment and disposal facilities such as sewage treatment works and landfill sites. Prospects for decentralized waste management whereby much of the waste generated within sections of urban areas is treated and disposed within the area of generation, have yet to be fully developed. Examples of closed-loop integrated water and waste management within housing complexes exist but require evaluation as to their acceptability, cost-effectiveness and replicability.

40. The lack of available land in suitable locations often forecloses optimal waste collection, treatment and disposal options and thereby increases the cost of waste management. Conversely, special opportunities exist for the location of new waste-disposal facilities. An example is the use of disused quarries for landfill. The potential use of low-lying lands for development purposes is still not adequately exploited.

41. The concept of planning zones, widely used to guide settlement development, when integrated with infrastructure-engineering considerations, could serve to segregate areas that are homogeneous in terms of, amongst others, their waste management requirements. Zoning could serve as a useful support to efficient and cost-effective waste management since it could be used to separate industrial waste systems from residential waste systems when such separation is desirable.

42. Few countries have sound national and local land use plans capable of directing settlement growth in ways that can avoid land use conflicts. Even when such plans exist, local authorities rarely have the ability to enforce them. The unprecedented rate of urban growth in recent years has compounded the problem. In most developing countries central and local governments have lost almost all control over urban growth which proceeds with little regard to land use and physical plans. It is estimated that for every 10 new housing units constructed in low-income developing countries, only one conforms with approved land use and physical plans. Under such circumstances, prospects for integrating waste management with development plans remain bleak.

43. In general, planning of human settlements does not take account of, and link, waste management with land use and physical development plans. While most industrial countries now use environmental impact assessments and public enquiries before projects are implemented, this procedure is rarely used in developing countries. Without such procedures, coupled with public review of the results, environmentally-sound planning is difficult to achieve. The improvement of existing informal settlements and the rapid increase in the

proportion of properly serviced settled areas are both essential to achieving control over urban growth. Due account will need to be taken of waste management requirements in planning such settlement upgrading and development work.

44. Clearly, one of the reasons why due account of waste management requirements in overall land use and physical plans is lacking is the unavailability of specific technical guidelines on precisely how this might be done. Some efforts, however, have been made in this direction. The most notable example is the environmental guidelines for settlement planning and management developed jointly by UNEP and UNCHS (Habitat). These need to be more widely known and adapted to local circumstances.

45. Besides the use of local physical and land use plans to support improved waste management, much can be done at the national and, in some cases, regional levels to incorporate environmentally-sound waste management principles within development plans. Unless waste management is assigned the requisite priority within national development plans and the corresponding authority given to generate and manage funds at local levels, it is unlikely that the sector will make substantive progress. Environmentally-sound waste management objectives and policies will first need to be incorporated within national development plans before they can be appropriately translated into actions at the local level. At the regional level, the movement of recycled materials from one country to another within the same region could enhance waste recycling by taking advantage of differences in technical capacities and raw material requirements.

V. TECHNOLOGIES FOR WASTE MANAGEMENT

A. Technology choice

46. Technology for waste collection, treatment and disposal will to a large extent determine the quality of environmental improvement that a waste management service is likely to achieve. Technology choice should have as an overriding objective the extension of present day waste disposal service coverage and the improvement of service quality, taking advantage of techniques beneficial to the environment to the extent possible. Resources available to provide waste management are scarce. The cost-effectiveness and affordability of the technology chosen is critical.

B. Conventional sewerage technology

47. Despite the fact that conventional sewerage provides the most convenient and perhaps most health-protecting way of disposing of domestic sewage and industrial effluent, substantial expansion of wastewater disposal services using this technology is constrained by its high capital cost. In addition, the system produces an end-of-pipe point source of effluent which, if not adequately treated, can have an adverse impact on the receiving environment. Another important consideration from the point of view of the environment and the sustainable use of resources is the fact that conventional sewerage systems demand large quantities of flush water to ensure the self-cleansing movement of solids within them. It is not uncommon for such flush waters to contain over 40 per cent of daily household water consumption.

48. In the 1960s and 1970s, many large cities around the world developed sanitation plans based exclusively on conventional sewerage for the entire urban area. Such plans were too expensive to implement and most of them have not gone forward. Conventional sewerage may cost $US 150-200 per capita, while 73 per cent of the population in developing countries live in countries with an average GNP per capita of less than $US 545. This means that even if these high-cost systems are built, few residents can afford the high connection fees and indoor plumbing costs. The system then operates below capacity, giving rise to maintenance problems. Given these constraints, the technology, in most cases, can neither be considered affordable nor environmentally-friendly.

49. Of course, in high density areas of developing country cities, there remain few, if any, alternatives to conventional sewerage. In fact, under such dense conditions of settlement, sewerage costs are reduced substantially since greater populations are served per unit length of pipe network and the adequate flow through the system avoids clogging. Unfortunately, much of the sewerage constructed in developing countries after independence has been in high-income areas with low population densities resulting in inadequate cost-recovery. It is in such low-density settlements that alternative forms of waste disposal may be most effective from both technical and cost points of view.

50. Much headway has been made in recent years in modifying conventional sewerage design standards to reduce costs. The shallow-sewerage system developed in Brazil and the small-bore sewerage systems are examples of such solutions. These modified systems may cost as little as a quarter of conventional sewerage. Therefore, the scope for a wider dissemination and application of these technologies is evident. In addition to the use of conventional sewerage in high density residential and commercial areas, these systems are generally appropriate for industrial areas. Strict control of quantitative and qualitative effluent criteria for discharging industrial wastewater into sewer networks will be required, however, in order to ensure that the combined effluent can be adequately treated. This may require partial pre-treatment of industrial effluents prior to their discharge into sewerage networks. While this will often be difficult to apply to existing industries, it should be considered for new industrial developments. Often, it is only a handful of larger industries which need to be monitored closely to ensure treatability of the combined wastewaters. In assessing the benefits of providing sewerage in industrial areas due account will need to be taken of potential increases in investments, labour and economic growth that the infrastructure is likely to stimulate.

C. Alternative sanitation technologies

51. There is a wide range of alternative forms of sanitation that are far cheaper than conventional sewers and sewage treatment plants but which are just as effective and hygienic. Many of these technologies, such as the pour-flush latrine and pit latrine, cost only a sixth the capital cost of conventional sewerage. Even more sophisticated technologies such as septic tanks can cost only half as much as conventional sewerage. Within this range of technologies lie options for human waste disposal which could be implemented to match physical conditions, social preferences and economic resources

available locally. Most of these technologies need far less water to operate and can be upgraded gradually as full waterborne sewerage systems become both needed and affordable. Many of these systems rely on the on-site disposal of wastes and are most suited for communities with low population densities and limited water supplies. The use of these in situ waste disposal options in less densely populated urban peripheral areas and low-density high and middle income communities presents one of the most promising ways of accelerating human waste collection service coverage. Several of these alternative sanitation technologies have been tried and proven effective in many countries.

52. Many problems still constrain the wider use of these alternative sanitation technologies. Many water and sewerage agencies and municipal authorities will not accept these technologies as legitimate alternatives to conventional sewerage. Even when accepted, there is a need to establish the requisite mechanisms for financing, community participation and the provision of septage collection services. While the identification and promotion of these alternative technologies has been spearheaded by the UNDP/World Bank Water Supply and Sanitation Programme and the UNCHS (Habitat) research programme, a more concerted effort at institutionalizing their application at local levels is urgently required.

D. Wastewater treatment

53. Sewage usually comprises a mixture of residential, commercial and industrial effluents which require treatment before disposal into the environment. The type of wastewater treatment technology to be used will be determined by the characteristics of the effluent, climatic conditions, the availability of land and of reliable power supplies, the characteristics of the receiving environments and the potential for treated wastewater reuse. As in the case with most infrastructure development programmes, system cost remains the overriding determinant of technology choice. A review of sewage treatment works conducted in most developing countries reveals that only less than 10 per cent of the installed capacity is operational. Even those facilities which are operational by-pass a large proportion of the wastewaters past the treatment works and whatever small proportion is finally treated is not subject to adequate process controls to ensure an acceptable final effluent. Few of the treatment works constructed have sufficient equipment, and in some cases, they lack sufficient personnel. The ability to operate and maintain freshwater treatment facilities remains the single most important factor governing technology choice.

54. Perhaps the cheapest and most robust wastewater treatment technology, eminently suited to the climatic conditions of most developing countries, is the waste stabilization pond system. The system is the simplest form of wastewater treatment and the most effective way of removing pathogens. Properly designed stabilization ponds produce a consistent effluent. Unfortunately, stabilization ponds require large land areas which are not always available, or, if available, the cost may be prohibitive.

55. More capital intensive plants, such as activated sludge plants, produce effluents with little organic and suspended matter. However, the effluents of these plants may not be of sufficient micro-biological quality to be

discharged into the environment. There are also problems in operating and maintaining these relatively complex processes. Where the provision of such complex wastewater treatment systems is the only technically and economically appropriate option, the establishment of long-term in-service training programmes, process control, and operations and maintenance is an essential element of the project. Some on-site sanitation systems and most sewage treatment plants produce sludges potentially hazardous to human health. The use of sludge drying beds and co-composting with the organic portion of solid wastes are two effective ways of dealing with sludges. After requisite storage, sludge thus treated can be applied in agriculture if heavy metal content is not too high. Sludge disposal at sea is still practised in many industrialized countries, causing serious damage to the marine environment. Sea outfalls are widely used in coastal zones with attempted use of dispersion techniques to reduce pollution concentration. This form of wastewater disposal, besides being extremely expensive, represents a long-term threat to marine life and a loss of resources to society. More information on the operational impacts of sea outfalls is required before suitable guidelines for their continued use can be advocated.

56. In national water resources and agricultural planning, the resource value of wastewater is often overlooked. Apart from the great value of water in arid, semi-arid and water-short regions, urban sewage contains valuable nutrients in the forms of nitrogen, phosphorus, organic matter and trace elements. Many urban areas in the Middle East area have been landscaped using treated sewage as irrigation water. However, treated sewage effluent may be more beneficially applied to irrigate agricultural crops. In this case, proper controls must be introduced to guard against health risks involved if pathogens are present in the effluent. WHO, in collaboration with UNEP, has prepared guidelines for the safe use of wastewater in agriculture and aquaculture.

57. Investments in sewage treatment account for between 15 and 30 per cent of the cost of an overall sewer reticulation, treatment and disposal system. Investments in sewage treatment rarely keep pace with investments in sewerage networks just as sewerage networks rarely keep pace with investments in water supply. Although use of treated sewage may provide a limited return on investment, no form of wastewater reuse in likely to recover the cost of sewerage. The major justifications for investing in wastewater reuse are the environmental benefits and the potential economic losses to society of the additional health risks associated with unorganized reuse. Due to the spatial and temporal variations of community and industrial wastewaters, reuse is not always feasible. Careful planning is required to match supply and quality of wastewater with requirements. This can entail the need for additional storage facilities. For sewage and sludge reuse to become more widely practised, the recycling of these wastes will need to continue to be the subject of research aimed at identifying safe and cost-effective options.

E. Solid waste storage, collection, treatment and disposal

58. The collection, treatment and disposal of solid wastes absorbs a substantial proportion of municipal budget and workforce. Despite this, urban solid-waste management services in many developing countries have failed to keep pace with demand and thus the proportion of population served and the

quality of the service have both steadily diminished in most developing countries. The absence of adequate planning and the use of inappropriate technology and poor maintenance have led to a serious wastage of municipal funds. The service provided in a majority of developing country cities and towns can, at best, be described as unreliable, irregular and inefficient.

59. Storage, collection, transport, and disposal are the four principal elements of any solid waste management operation. Between 70 to 80 per cent of the total expenditure incurred in solid-waste management operations goes into solid-waste transport. This is where most efficient solutions are most urgently needed. One of the most important problems is in purchasing and operating inappropriate vehicles. While the efficiency and effectiveness of a collection system are primarily determined by the equipment used for waste transport, they are none the less intimately related to the methods of waste storage and collection. Compatibility among collection, transport and storage is rarely ensured. Storage facilities are rarely animal-proof, insect-proof and weather-proof. They are not washable and are not robust enough to meet the exigencies of normal use. Storage volumes are rarely adequate. Collection, whether communal, block, curbside or door-to-door is rarely regular and reliable. The cooperation of households is therefore often not forthcoming. Yet the competence of local administration is often judged primarily by the performance of its refuse-collection system.

60. The use of inappropriate, often imported, technologies for waste collection remains a pervasive problem in many urban areas. Compactor vehicles designed to handle light-density wastes in industrialized countries, for example, are often totally unsuitable for developing country wastes which are naturally dense. Likewise, the choice of standardized large vehicles designed for the more formal parts of the city can exclude other large sections such as high density slum and squatter areas, which cannot be reached with large vehicles. The use of vehicles beyond their economic life, the failure to balance between the extent of mechanization and the cost of labour, the failure to take into adequate account the prevailing socio-economic and cultural factors and the provision of equipment beyond the local capacity to maintain it, are the principal factors determining "inappropriateness" of vehicle technology. The use of inappropriate collection vehicles reduces service performance. There are examples where as much as 60 per cent of the fleet is out of service at any one time.

61. Bilateral aid and other forms of assistance are often tied to the supply of overly sophisticated refuse-collection equipment. Some governments have accepted equipment without regard to its appropriateness. These forms of assistance often have as their purpose not only the supply of capital equipment from the financing country but also capturing the market for needed spare parts. There is often little consideration of the compatibility of such equipment with local conditions. Changes in aid policies and a firm commitment to give priority to the manufacture and application of equipment that satisfies local needs is urgently required. Such changes can only be brought about through increasing the awareness of local decision-makers and donors alike. UNCHS (Habitat) has attempted to promote the use of appropriate equipment through a technical publication devoted to the subject. Many examples of cost-effective and efficient refuse equipment exist and their development and wider application should be pursued. In addition, there is considerable scope

for optimizing the utilization of existing systems through investment in improved maintenance techniques.

62. The most widespread and economical method of refuse disposal is deposition on land. If done in a sanitary way, this method causes minimal pollution and land degradation effects. But the least expensive and most used disposal method in the short run is simply to dump the waste in spite of the resulting degradation of air, water and soil. While guidelines exist for the planning and operation of sanitary landfills, there has been little commitment to adopt and apply them in most developing countries. Properly designed landfills can also serve as a useful source of energy. The economic and operational viability of such energy recovery schemes have been proven in some countries such as Brazil. However, a more thorough evaluation of this option and suitable techniques for its application is warranted before the technology is transferred more ubiquitously. Incineration is often seen as an attractive alternative to land disposal because it appears clean and modern. In some situations, especially in industrialized countries, it has proven the best disposal option when haul distances are long and heat energy recovery desirable. However, in developing countries, the incineration option can cost as much as 10 times the landfill option and is inappropriate for hospital wastes. The low calorific value and high moisture content of developing country refuse often make incineration unsuitable. Most incinerators installed in developing countries have experienced serious operational problems and premature failure. Even when incineration is used, a landfill site is still required to dispose of ash and residue.

63. Composting the organic fraction of refuse has the advantage of reutilizing the wastes instead of disposing of them. In practice, however, most composting operations cost 2 to 4 times as much as landfilling and present operational problems. Lacking demand from the agricultural sector, some operations have generated large amounts of unsold compost. On the other hand, there are examples where compost-producing operations have been run at a profit as commercial operations. A number of factors suggest that composting as a disposal option will gain importance over the coming decades. Lack of landfill space, increasing cost of landfill operations, especially when strict criteria for sanitary landfilling are enforced, and recent developments in cheap and effective ways of composting, such as the forced aeration technique, and the increasing use of environmental accounting techniques for decision-making are all destined to make composting a more viable option with time. Applied social and technical research is required to advance this form of waste disposal.

64. Another aspect of waste management that is destined to see increased application is the obtaining of economic benefit from the waste through resource recovery. The resource recovered can be energy, raw materials, reusable products or a new product. Quantities of waste to be disposed of are reduced. In general, industrialized countries practise less resource recovery than developing countries. However, many countries today are investing in waste recycling in response to the increasing cost of disposal and lack of landfill space. Recently, some dramatic measures have been introduced recently to favour recycling. In Newark, New Jersey, USA, for example, the local authorities subsidize recycling firms at the rate of $US 30 per ton and still accrue savings against the $US 150 per ton it would cost them for disposal.

65. Much of the resource recovery in developing countries involves scavengers and used materials merchants. Scavengers, in particular, are often considered a hindrance to municipal waste disposal operations since they tip and scatter wastes around storage containers. Ways of avoiding such conflicts and increasing waste recycling productivity are required. One way is to incorporate scavengers into municipal waste operations. For example, they can be designated as official used-materials merchants and given training and status upgrading. An increasing amount of recovered materials are reprocessed by small producers outside the formal sector. As much as 30 to 40 per cent of developing country refuse may be reprocessed through these small industries. The rest is primarily organic and can be composted. Ways of strengthening and supporting these informal small-scale cottage-based waste recycling industries is a subject that merits further research.

F. Waste technologies for urban informal settlements

66. As stated in the preceding section, urban informal settlements have regularly been excluded from access to waste management services. Yet in some cities these settlements are growing twice as fast as the formal sections of the city. It is the residents of these areas who bear the brunt of the insidious social and health consequences of inadequate waste management. Problems of access and lack of paved roads prevent municipal refuse collection vehicles from entering these settlements. Conventional sewerage systems rarely reach informal settlements and even if they do, the systems seldom function adequately. Few, if any, on-site sanitation systems are likely to be feasible because of high population concentrations. Even so there is little dispute that health and environmental problems are most critical in these hard-to-service areas.

67. Some advances have recently been made in developing location specific waste management technologies such as, for example, the dumper-based solid waste collection vehicle capable of gaining access to areas with narrow unsurfaced roads. Similarly, the development of the shallow sewer system adapted to fit both the physical and socio-economic conditions of low-income informal settlements represents an advance in waste management technologies for hard-to- service informal settlements. More resources are needed to deal effectively with the needs of these communities.

68. Much can be done to support the development of technologies and equipment suitable for informal settlements, when possible taking advantage of local manufacturing capacity with its reduced operations and maintenance costs. Community participation and management will be important to the success of the programme.

VI. WASTE PREVENTION, MINIMIZATION AND REUTILIZATION

A. Introduction

69. A strategy of waste prevention, minimization and reutilization should become the foundation of future solid waste management programmes. Waste minimization can be achieved through modification of industrial processes and through changes in the design and use of products. A wide range of incentive-providing waste minimization policies and instruments exist and their wider

application will encourage the conservation of resources. Waste minimization involves the entire production and consumption cycle including the fate of products after their use.

B. Principles of waste minimization

70. The first approach to waste minimization should be through product design changes, industrial process changes, material substitution and consumer behaviour modification. Then comes recycling. Finally is the safe disposal of wastes that cannot be recycled. This hierarchy of waste management systems represents a shift in environmental protection strategy from end-of-pipe controls of wastes to avoiding their generation.

71. Cradle-to-grave waste minimization strategies are applicable to industry, commercial enterprises, governmental institutions and private individuals. There are many options at the industrial processing stage to reduce waste through raw material substitution and redesign of products and processes. For example, shredded used plastic products can substitute for a proportion of virgin polymer in the manufacture of new plastic products. Recycling within the process is also possible; for example, the recirculation of cooling water through a closed-loop. Training of employees and a sound preventive maintenance programme can avoid wastage and loss in industrial processes. Experience has shown that industrial process modification can, in addition to reducing raw materials and energy costs, also reduce waste disposal costs, reduce downtime and enhance productivity. They lower production costs. The wide range of process modifications that can be made with the objective of waste minimization requires evaluation and wide-scale dissemination.

72. It is especially necessary to reach the small- and medium-scale industrial producers including the informal sector operators that may not have financial or technical resources available to research waste minimization options for themselves. Also, as mentioned above, informal groups have been successfully converted into recycling cooperatives and granted concessions for collection and recycling. Such cooperatives are operational in Medallin, Colombia; Ciudad Juarez, Mexico; and Cairo, Egypt. Such informal waste recycling operations could also be encouraged through technical and financial assistance.

73. Waste minimization through product modification has so far received little attention but has considerable scope. Changes in product content, form, durability and reparability can have a significant impact on wastes generated from the discarding of used products. Much research needs to be carried out to evaluate the design and use of products from a waste minimization perspective. Incentives for increased use of more environmentally benign products need to be explored. There is a need to evaluate product design options that will minimize waste through raw material substitution, improved product durability and, most importantly, reduced packaging. Elaborate and superfluous packaging is often used to please costumers but the costs are also passed on to the costumer. Informing the public and giving them the choice to purchase environment- protecting goods is one way of reducing packaging and stimulating a market for recovered materials. Another option for reducing packaging is the levying of a tax.

The German Government will, by law, require a deposit of about $US 0.30 starting in January 1993 on packaging for drinks, cleaning material and paints. The law obliges the retailers and distributors to accept used packaging from consumers. Industrial designers could focus on developing durable products rather than the single-use items, razors being an example. Product taxes based on such criteria could be developed.

74. Selective purchasing by informed buyers may well be the strongest incentive to cause manufacturers to produce low-waste consumer products. Labelling of products giving the "cradle-to-grave" environmental impact of consumer goods is already taking place and will probably become increasingly important. Public interest groups and education programmes also have a role to play in providing information to consumers. Environmental policies should encourage private sector research and development towards waste minimization. Waste minimization is not only confined to solid wastes but applies equally to sewage. The quantity of domestic wastewaters generated is a function of water usage. Various options such as flow-restricting devices, appropriate tariff policies, public education, and flow metering could reduce consumption dramatically and thereby generate less wastewaters.

C. Instruments for waste minimization

75. Recourse to legal instruments such as codes of practice, regulations and local by-laws could be used to promote waste minimization. In the United States, for example, a few states have mandatory statewide laws requiring residents to deposit recyclables separately at the curbside. Some states require source segregation of various materials by category. Regulation can also be used to ensure material reuse to protect the environment and alleviate shortages. Korea's Waste Plastic Recovery Law is an example. Codes of practice can predetermine and specify technical options and standards and can be used to ensure, for example, the abstraction of gases from landfills. These could additionally be supported by permits and licenses which in turn could ensure operational compliance with accepted practice.

76. Foremost among the instruments designed to provide householders and both the private and public sectors with incentives to reduce waste is the application of user charges for waste services that reflect the marginal cost of providing the service. For example, there is abundant evidence that consumers will reduce non-essential uses of water if water supply tariffs reflect full production costs including sewerage treatment and disposal. Various user charge mechanisms such as the pay-per-bag, or charge-per-can have been implemented. These have been successful in reducing solid waste generation by between 25 and 50 per cent. Where bags are used, residents pre-purchase stickers which they attach to the bags intended for municipal collection. In other cases, residents are charged by the number of cans they fill. Most of the reductions achieved by these tariff systems are attributed to the separation and recycling of glass, paper and cans.

77. Product surcharges are another form of tariff, designed to lead to the use of alternative, less environmentally damaging, products or to cope with some of the environmental impacts such products are likely to create. Although they could be used to direct production patterns and consumer

behaviour, such as the use of reusable beverage containers instead of non-returnable containers. It is important to establish product charges sufficiently high to provide an effective incentive to change behaviour.

78. The deposit-refund system, applied ubiquitously on beverage bottles, is designed to minimize waste through recycling. The system has worked efficiently both in developed and developing countries. The economic incentive is usually adequate to produce the desired behaviour. The rate of recycling is known to reach between 80 and 90 per cent, even in high income countries such as the United States, Denmark and Finland. Subsidies to waste authorities and the private sector have also been successfully utilized to support waste minimization and resource conservation policies and objectives. Such subsidies are usually focused on the installation of low-waste technologies and waste recycling schemes.

VII. CAPACITY BUILDING FOR WASTE MANAGEMENT

A. Introduction

79. Improving solid waste and sewage management requires changes in technical, social, financial, planning, legislative and institutional practices at the community, local, national, regional and global levels. In order for such changes to be translated into practice, a considerable effort is required at building up sufficient capacity within concerned institutions and organizations. Education, training, institutional reform and information exchange are some of the means by which local and national governments can build the capacity to manage wastes. A broad effort is needed including the mobilization of community support and the involvement of NGOs and the private sector.

80. Capacity building programmes need to focus on individuals, including officials, professionals, technicians, researchers, trainers and the public at large. They also need to focus on public and private sectors institutions, NGOs and community organizations.

81. Conventional capacity building efforts have, in the main, focused on a one-way process where established information techniques and procedures are transferred from advisors and trainers to recipient officials and individuals. A more interactive two-way process is advocated for future programmes.

B. Legislative issues

82. In developed countries, and more so in developing countries, environmental laws and legislations still remain largely inadequate and those entrusted the task of enforcing them have little capacity or authority to implement them. The creation of a programme for developing requisite environmental laws and other legal instruments for the control of waste pollution should be a priority consideration in any capacity-building effort. While legislative instruments should form an important part of the programme, equal importance should be assigned to identifying and making operational the wide range of economic incentives for improving waste management. Clearly for such legal and economic instruments to be useful, they would need to be provided with

the appropriate institutional authority and resources to enforce them. The creation of adequate institutional capacity, both in terms of human resources and equipment, to monitor pollution should also be a priority consideration under this programme.

83. Much of waste-management planning in developing countries is still done by foreign consultants. This practice is neither conductive to in-country capacity building nor is it sustainable. The result is the almost total lack of indigenous knowledge in planning waste management. Multilateral lending agencies often place conditions for contract bidding prequalification which are beyond the means of local firms to satisfy. This practice requires prompt modification if local capacities are to be built. Every effort to ensure the use of local professionals must be viewed as a positive contribution towards capacity building even if it is the private sector that benefits. Fears of reduced quality controls through the use of local consultants are totally unfounded and can in any event be kept in check through external reviews. Similarly, there remains much scope for the use of local waste-management equipment whenever possible. Efforts to build national waste-management capacities should be founded on these principles of local capacity utilization if sustainability is the objective.

C. Education and training

84. There have been serious shortcomings in traditional forms of professional and technical education for waste management. An education and training strategy should take account of the wide range of technologies, especially low-cost technologies, available for waste management; participatory approaches to planning and implementing programmes; ways of minimizing wastes and promoting reuse; and the use of environmental impact assessment techniques and environmental accounting. Little or no education and training is now provided to those employed in managing wastes, especially in developing countries. Consequently, those engaged in the sector undertake the task at grave risk to their health and have little appreciation of the impact of their activities on the environment. Training and education programmes for public and private professionals and technicians are needed. Standard academic programmes should be modified. Short courses should be developed for senior decision-makers, professionals and workers. Mechanisms for ensuring citizen participation are crucial for gaining the support of the public. Sound waste management practices can be included in school curricula. At the international level more programmes are needed to share experience especially among developing countries.

85. A critical problem in waste management is the low priority and status assigned to waste management professionals, in general, and maintenance workers in particular. The upkeep of waste management infrastructure assets, to avoid their premature replacement and their optimum capacity utilization can only be assured if institutions responsible for waste management are endowed with sufficient and skilled staff. A programme aimed at promoting waste management infrastructure operation and maintenance should form an integral component of an overall capacity-building effort. Implicit in such a programme should be the development and applicaton of sound maintenance

management procedures and practices and the upgrading of the skills and status of maintenance workers. Prospects for facilitated information and technology transfer on maintenance equipment and procedures should be built into such a global capacity-building effort.

VIII. APPLIED RESEARCH AND INFORMATION EXCHANGE

A. Introduction

86. There is a need for applied research and information exchange on up-to-date waste management techniques. Areas where advances in waste management are urgently needed have been identified in preceding sections of this report.

87. To effectively improve knowledge, understanding and practice, through the mutually reinforcing processes of applied research and information exchange, there is a need for effective communication between the research community, decision-maker and the public.

B. Research needs

88. Research should be focused on the following areas:

(i) Techniques and modes of delivering cost-effective waste management services in high density informal settlements. Solutions will involve community participation, the increased role of women in decision-making and innovative forms of revenue generation. The development of suitable waste management equipment responsive to local conditions should be a priority consideration.

(ii) The preparation of international and local guidelines for the siting and management of waste facilities and techniques for their environmentally sound management. Such guidelines should include information on environmentally safe ways of reclaiming used waste disposal sites.

(iii) Ways of minimizing wastes and changing production and consumption patterns. The wide range of methods and incentives, including fiscal and legislative instruments, which are being used will need to be identified and, through applied research, translated into overall socio-economic development policies and plans.

(iv) Ways of recovering resources from waste. Resource recovery research should focus on: the safe use of treated sewage in agriculture and industry; the modification of waste management systems in order to conserve water; the safe use of sewage sludges in agriculture; the recycling of solid wastes through source separation and reprocessing through small-scale cottage based waste recycling industries; the source separated *in situ* composting of the organic fraction of solid wastes; and the recovery of energy from landfill sites.

(v) The identification of cost-effective ways of treating both sewage and industrial effluents in developing countries and the preparation of technical and policy guideline documents on this subject.

(vi) Ways of mobilizing and generating resources for waste management and effective ways of managing such resources.

(vii) Options for increasing capacity utilization of existing waste collection and treatment facilities through improved maintenance techniques and practices.

(viii) Ways of developing project appraisal methodologies which go beyond present-day cost-benefit analysis and include risk-assessment and impact-evaluation methods, based on environmental accounting.

C. Information exchange

89. At least eight distinct audiences for information on waste management can be identified - each with its own information needs: senior policy-makers and aid agency officials; senior specialist staff; technical staff; teachers and trainers; researchers and research organizations; implementing NGOs and private sector developers; public workers in the waste collection sector; and scavengers and informal-sector waste collectors and reprocessors. Information is often aimed at only one or two of these audiences and thereby only partially effective. Purpose-made information is required, tailored to the needs of each audience. Much can be done to identify the audiences needing information on waste management and to define the type and nature of information to be supplied to each audience group.

90. Little or no effort is now being made to adapt technical reports for particular audiences. Likewise, training institutions often pay too little attention in working with those they train to identify gaps in knowledge. Technical assistance agencies give inadequate emphasis to analysing and synthesizing field experiences and to drawing on the knowledge of their field staff to increase knowledge in waste management. The lack of overall regional and global programmes to undertake this information processing is, in part, responsible for this shortcoming. Procedures for systematically analysing and synthesizing field experiences and projects and to draw on the knowledge of field staff in preparing information materials on waste management should form an integral part of programmes aimed at facilitating information exchange on waste management.

91. Few publications exist on the siting and management of waste facilities and technologies for their treatment and reclamation. Even where such information is available the information does not reach a wide and targeted audience. Little effort is presently made to produce international guidelines and available information is inadequately disseminated. Publications are rarely reviewed in relevant periodicals and even less frequently reproduced in a synthesized form in technical journals. Many of the areas presenting information gaps require extensive research before authoritative information can be produced for dissemination. Much can be done to strengthen existing newsletters, journals and periodicals and to encourage the review of information materials on waste management as they emerge.

92. There is a need to establish close linkages between information exchange programmes and ongoing applied research programmes in order that the findings of the research programmes can be widely disseminated without delay. There is also a need to ensure the rapid translation of emerging publications for distribution to the various regions.

93. Networking - an effective mode of exchanging information - is almost non-existent. Few efforts have been made so far to establish such networks. Developing such joint multinational and local collaborative dissemination programmes is a prerequisite to promoting information exchange at the scale required. There is consequently a need to identify existing information networks and their scope and coverage and integrate those concerned with waste management into a common network.

IX. FUNDING WASTE MANAGEMENT FACILITIES

A. Introduction

94. Financing of waste management facilities is a critical issue which basically determines the rate at which service coverage can be expanded. In developing countries, the municipal income base from which revenues are derived is much smaller than in industrialized countries; often only two to five per cent of the base available in industrialized countries. Yet, the cost of equipment and vehicles, is likely to be higher for developing countries.

B. Economic framework

95. Unlike industrial pollution control, for which an economic theory has been developed, municipal pollution control has not yet been placed within an adequate framework. The main reason for this is that pollution control through improved waste management provides both a private and a public good and it is not easy to define the proportionate benefits. However, some advances have been made to relate demand for waste services to the quality of service provided. For example, demand functions for solid waste collection have been constructed which relate willingness to pay to quality of service provided in Chicago, United States of America, based on factors such as frequency of collection, convenience of collection point etc. Similarly there are a number of examples where residents of urban informal settlements pay private individuals for the removal of both human and solid wastes, thus demonstrating a willingness and ability to pay for waste services. While these examples demonstrate the extent to which individuals are prepared to bear the cost of waste management, neither households nor local authorities appear very concerned about the environmental spillover effects, such as downstream or groundwater pollution, resulting from inadequate municipal waste treatment and disposal. Until municipal treatment and disposal services are viewed as a public good and effective local, state and national actions are taken to control spillover effects, it is unlikely that much progress will be made in reducing waste-related pollution.

C. Revenue generation

96. Funding for service with mixed private-public benefits could be from a combination of internal sources, such as user charges and benefit taxes, and external central government transfers such as revenue sharing, equalization grants and matching grants. The blend should depend on the incidence of environmental benefits and extent of potential spillover effects. However, many problems exist which constrain the generation of needed internal and external sources of local government revenue. Waste treatment facilities are rarely given a high priority in the face of competition from more directly productive infrastructure facilities.

97. Financial intermediaries have been created in several countries and include municipal development banks and public works banks and in some cases specific lines of credit for waste management have been established under such arrangements. For example, Mexican municipalities may borrow from BANOBRAS against separate lines of credit created for water and sewerage works and solid waste management. Multilateral financing institutions such as the World Bank have provided loans to establish such lines of credit with specific agreements on interest rates and eligibility criteria for on-lending. The State Government of Tamil Nadu, India, has designed a new Municipal Urban Development Fund for municipalities. They have created an interactive computer model which allows staff to negotiate a package of loans and grants tied to revenue and expenditure performance targets for each municipality.

98. The use of soft loans from both multi-lateral financing institutions and, more particularly, from central governments for meeting environmental objectives is not fully developed. There are four main problems with central government grant programmes in developing countries: (a) the level of funding may fluctuate unpredictably from year to year, making local budgeting difficult; (b) in some cases, grant funds are earmarked for capital construction, encouraging local governments to build new facilities which they cannot operate and maintain adequately; (c) grant funds are often used to make up deficits in operating budgets, in essence rewarding those governments which perform poorly in mobilizing resources; and (d) the level of grant funds is shrinking in many countries due to the fiscal crises facing central governments in general. In a few cases, central governments are transferring additional resources to local governments to accompany decentralization of public services. For example, in Colombia a portion of the sales tax is provided to local governments, and in Morocco a start will be made to distributing 30 per cent of the national value added tax to local governments. However, the broad trend is towards a reduced, or stagnant, level of funds transferred from central government to local authorities.

99. Perhaps the biggest problem in improving waste management infrastructure is the lack of a service performance orientation on the part of concerned government agencies. Most government officials do not have a client-orientation toward citizens and do not pay sufficient attention to the quality of public service actually delivered. Consumers are unlikely to pay for services poorly delivered. While performance measurement in local government has enjoyed some popularity in some industrialized countries, it is virtually unknown in most developing countries.

100. Internal revenue sources such as property taxes, benefit taxes and user charges finance the majority of municipal operating budgets, at times reaching 75 per cent. These revenues sources often fail to cover capital costs. A recent survey of an Asian country found that financing needed to bring municipal services up to an acceptable standard was about six times the level that the local sources could sustain. In developing countries local governments often lack appropriate legal authorities for revenue collection and achieve only poor yields from those they have. Property taxes are the most important source of revenue for most local governments but rates are usually set by central government ministries and remain unchanged for long periods: it is not uncommon for some local governments to maintain the same tax rate for over 15 to 20 years. Property tax collection has routinely been running at only 25 to 40 per cent of tax billings in most cities. Improving property records or cadastre, updating assessment records, improving billing and collection procedures are some of the reforms urgently required to improve local revenues. Investments in such reforms have proved worthwhile; in New Delhi improved collection procedures doubled revenues between 1986 and 1987. Tunisia increased property tax collection from 35 per cent to 70 per cent. Where local authorities rely on too many sources for their local revenue, eliminating small and unproductive revenue sources can improve overall revenue generation performance. Where water and sewage authorities exist, sewage rates charged are usually only a fifth what is required for capital repayment and operation and maintenance of sewerage and sewage treatment facilities. Shortfalls in revenue generation are compensated by cutting back on sewage treatment. High connection fees will discourage connections. By incorporating such fees within the overall tariff structure the connection rate can be increased. Some relief is obtained through the use of reduced cost sewerage systems. The State Water Authority in a Brazilian North-eastern State was only obliged to demand a 40 per cent surcharge on water rates to recover full cost of a shallow sewerage system.

101. Low-income communities, especially those in informal settlements, because of their lack of legitimate status, pay no municipal taxes, and this has often been used as the principal argument against providing these communities with municipal services. The issuance of land-title deeds is often necessary before municipal revenues can be derived from these communities. It is often assumed that these squatter communities are unable or unwilling to pay for urban services. However, in fact they often pay more to government surrogates for a vastly inferior waste service such as nightsoil and septage disposal than is charged by municipal authorities for sewerage. Recent experience also indicates that these communities often consider the payment of municipal taxes and service charges a positive means of obtaining legitimacy in the overall processes of the urban economy. In view of the limited revenue potential the use of low-cost technologies is fundamental to increasing service coverage. The single most important constraint to the wider use of these options is the lack of financing mechanisms for paying for these systems through monthly charges. Municipal and water authorities have favoured conventional service development over low cost options.

D. Public-private partnership

102. Waste management services can often be delivered through management contract arrangements, or through purely privatized operations. This option has yet to be fully exploited in developing countries. For municipal solid waste disposal, competitive bidding for small collection districts is often the least- cost option. There are few economies of scale and large economies of contiguity, so that a city can be divided into several collection districts of, for example, 50,000 to 200,000 people. Small local firms can deliver services on this scale so that easy entry/exit conditions exist and competition is fostered. It has also been found that the management of waste plants, transfer stations and landfills can be contracted out by competitive bidding. This takes place to some extent in industrial waste management. Where specialized services are required that are not readily available in-country, competitive international bidding can be used. Build-operate-transfer (BOT) arrangements may be applicable, and may be a means of mobilizing needed investment financing through the private sector. This may be an appropriate method of financing resource recovery facilities such as composting and pyrolysis plants, where operational skills are paramount and commercial marketing risks can be assumed by the private investor.

103. Municipalities usually retain statutory responsibility for service provision. Entry of the private sector will only be successful where open competition exists, and where local governments have sufficient technical capacity to monitor performance and supervise private service delivery. The informal sector already has an active role in resource recovery and recycling of solid wastes in most developing country cities. In some cases, these informal groups have been successfully converted into recycling cooperatives and granted concessions for collection and recycling.

E. Measures for improving waste funding

104. From the foregoing discussion it is evident that funding for services could come from a mix of user charges, benefit taxes and central government transfers and be appropriately priced based on the following principles for domestic wastes:

(i) Local sewage and refuse collection operations be paid for through user charges or benefit-taxes; volumetric charges to be preferred wherever feasible, otherwise, property taxes or flat rate service fees could be applied. Cross-subsidies be targeted at benefiting the poor.

(ii) Long-distance waste transport such as sewer interceptors and refuse transfer stations and disposal works such as treatment plants and landfills be paid to the extent possible from user charges and local taxes, as a means of applying the polluter pays principle.

(iii) Focused central transfers such as matching grant facilities be utilized where pollution spillover is possible and be made in proportion to the potential magnitude of its impact.

(iv) Recurrent operation and maintenance costs form an integral part of tariff computations and be directed exclusively for this purpose after collection.

105. The following principles could apply for industrial wastes:

(i) In all cases, the full costs of providing urban waste collection, transport and disposal services be recovered through user charges (Polluter Pays Principle).

(ii) Enterprises be allowed to reduce their costs by providing their own treatment and disposal facilities, which may be a more cost-effective solution.

(iii) Industries discharging into municipal sewers meet pre-treatment requirements at their own expense and pay a sewer use fee based on both volume and strength of discharge. The basis for such a fee ideally would be the marginal cost of treating the industrial waste at the municipal plant.

(iv) Solid wastes going to municipal landfills pay full "tipping fee".

(v) Costs of regulatory programmes by State and local governments be financed from earmarked pollution taxes and fines.

X. CURRENT RESPONSES AND MAJOR ACTIVITIES

106. Many important initiatives in improving the management of human wastes, sewage and solid wastes are currently underway. These include a range of regional and global programmes and some concerted inter-agency initiatives. Some of these are presented below. The list is by no means comprehensive and is only intended to be illustrative of current responses to the problem of waste management.

107. WHO collects, processes and disseminates all available information on endemic and epidemic diseases associated with wastes. It also advises its member States on effective ways of managing their wastes as well as undertaking surveillance of related infectious diseases. In addition, WHO encourages research on development of vaccines and other preventive practices including the design of health education campaigns. WHO's High-Level Commission on Health and Environment has recently assessed the health impact of wastes in the urban environment.

108. The global, UNDP/World Bank Water Supply and Sanitation project established during the International Drinking Water Supply and Sanitation Decade (1981-1990) continues to make contributions to building national capacity for waste management and, in particular, human waste and sanitation. The programme has been responsible for identifying and promoting a range of low-cost technological options for human waste disposal and has established regional training centres. A parallel programme is the UNDP/World Bank resource recovery programme which has been instrumental in identifying various technical options for recovering resources from all forms of solid wastes and sewage.

109. The Urban Management and Environment component of the joint UNDP/World Bank/UNCHS (Habitat) Urban Management Programme represents a major coordinated approach by the United Nations. One priority activity of this programme is the development of strategic options for pollution control and waste management. Recent work on waste management has focused on regulatory and economic instruments for, among others, waste management. The programme is also strengthening its national and regional capacity building operations through the use of an extensive network of national and regional experts and institutions.

110. Under UNCHS (Habitat)'s research programme on settlement infrastructure and environment, the Centre undertakes research on waste management and has produced various publications, computer programmes and other decision-making aids and tools. Much of this research has focused on options for waste management in high-density urban informal settlements and on waste recycling and reuse in developing countries. UNCHS provides assistance to plan, implement and manage improved waste collection, treatment and disposal facilities under its Technical Co-operation Programme.

111. Global and regional multilateral financing institutions have been at the forefront of lending programmes covering waste management infrastructure development. With the launching of the International Decade on Drinking Water Supply and Sanitation many bilateral agencies are actively supporting waste management and pollution control programmes in almost all developing countries.

112. UNICEF's Urban Basic Services Programme represents another initiative which includes the provision of waste management services. The programme has acted as a positive catalyst in initiating actions to improve waste management in low-income settlements.

113. UNEP in collaboration with a variety of other United Nations agencies including WHO, FAO and UNCHS (Habitat) has sought to contribute to the environmentally sound management of wastes by supporting the development of various sector-specific and cross-sectoral environmental guidance documents such as the safe reuse of wastewater in agriculture and the planning of human settlements.

114. ESCAP's citynet programme aims to provide a network for the exchange of information and acts as a forum for discussing, among other things, urban pollution problems. The programme has two groups of audiences - namely local governments and NGOs - and has a revolving chairmanship among participating cities. The programme prepares a calendar of activities which includes seminars, workshops and staff exchange programmes.

115. There is an African Urban Management project executed under the auspices of the International Federation of Institutes for Advanced Study and co-ordinated by the Institute of Environmental Studies at the University of Toronto. The participating institutions are predominantly professional

groups, teaching and training and research establishments and NGOs working in Africa. The project addresses concerns of urban waste management and pollution control.

116. OECD examines measures affecting source reduction and recycling on domestic solid wastes focusing on packaging materials and prepares publications on the subject. OECD also undertakes activities to distinguish between hazardous wastes and industrial waste materials which could be recovered.